NUTRIENT-INDUCED CHANGES IN THE SPECIES COMBINATION OF MEADOW ASSOCIATIONS IN AN IRRIGATED SOLONCHAK-SOLONETZ SOIL IN THE DANUBE VALLEY

GY. BODROGKÖZY and I. HARMATI

Botanical Institute of the Attila József University and Agricultural
Experimental Institute of the South-Hungarian Plain, Szeged.

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The more and more intensive drainage and drying up of the saline inland-watered areas of the Danube valley has caused, since the nineteen-twenties, a progressive transformation of vegetation (HERKE, 1962). The xero-halophilous vegetation, spreading over a larger and larger area, reflects the mosaic-like soil changes depending upon the inland-water conditions. The species combinations of associations taking place here demonstrate, depending upon the cropland conditions, considerable differences concerning both their level configurations and species numbers. The flora of the less saline soils with arranged water-system is the most developed, protruding island-like from the level of watered flats.

On the other hand, the species combinations of associations observed in the solonchak and solonchak-solonetz soils in the deeper-sited zone are the poorest, containing at most not more than three-four species as a consequence of the salt accumulation on or near the surface.

The question was raised how to produce multilevelled grasslang-cenoses which would be more developed than the saline meadow, resp. pasture associations *Lepidio-Puccinellietum*, resp. *Lepidio-Camphorosmetum* which dominate large areas at present. The experimental phytocenology may approach the solution of problem in two ways:

(1) By making the impacts considered to be satisfying (soil-amelioration, fertilizer-administration, irrigation, as well an aversowing parallel with them), starting from the existing saline meadow cenoses.

(2) By forming new phytocenoses in the place of existing cenoses, apart from employing the above mentioned treatments.

It is obvious that the most adequate answer to the raised question can be given if started in both ways together. In this paper we want to give an answer only concerning the way outlined in point 2.

The changes in cenoses of meadow associations as a result of fermentizer doses, resp. their measuring on an experimental basis, have been treated of by several authors, so far (KRISTE and WALTER (1955); KLAPP (1927, 1962). The effect of mineral fertilizers on the *Papilionaceae* and *Gramineae* components was examined by CORDUKES and co-workers (1955) and ECKSTEIN (1934). The influence of nitrogen on the same species groups by GRANT and BROWN (1961); in case of meadow associations by KREIL and co-workers (1961). BALÁZS (1961) has dealt with the importance of lawn fertilization. The geobotanical connections of the changes of natural lawn associations induced by fertilizer administration are treated of by the papers of SIEBOLD (1958) and RUMBURG and COOPER (1961). The effects of fertilizer doses at meadow associations, in case of different cropland factors, are described by SALVADORI (1954) and SCHECHTNER (1961). The general connections are summed up by SIEBOLD (1958).

First I published some data concerning the synecological changes of meadows of saline soil in the Danube valley as a result of different fertilizers (1958); And about similar connections of hayfields in solonetz soils the experimental results from H o r t o b á g y give a picture (1960, 1962).

Some results of lawn cenosis valuation by recent methods were obtained at the Danube sector of Fülöpszállás where we tried to valuate the quantity of production, as well, apart from the changes of dominance relations at any species (HARMATI—BODROGKÖZY, 1965; BODROGKÖZY—HARMATI, 1966).

Methods

For clearing up the questions raised in connection with the change of meadow association of solonchak-solonetz stilts, an experiment series was arranged in the Experimental Settlement for sodic soil amelioration in S z u n y o g p u s z t a (Kiskunlacháza) in the framework of a scientific cooperation program of the Institute for Botany of the Attila József University and the Agricultural Experimental Institute of the South-Hungarian Plain, in the Autumn of 1963.

The treatments of the four series experiment, arranged according to the split-plot system, comprised both the possibilities of the amelioration of alkali soils and tohose of the fertilizer administration. Their combination proved to be:

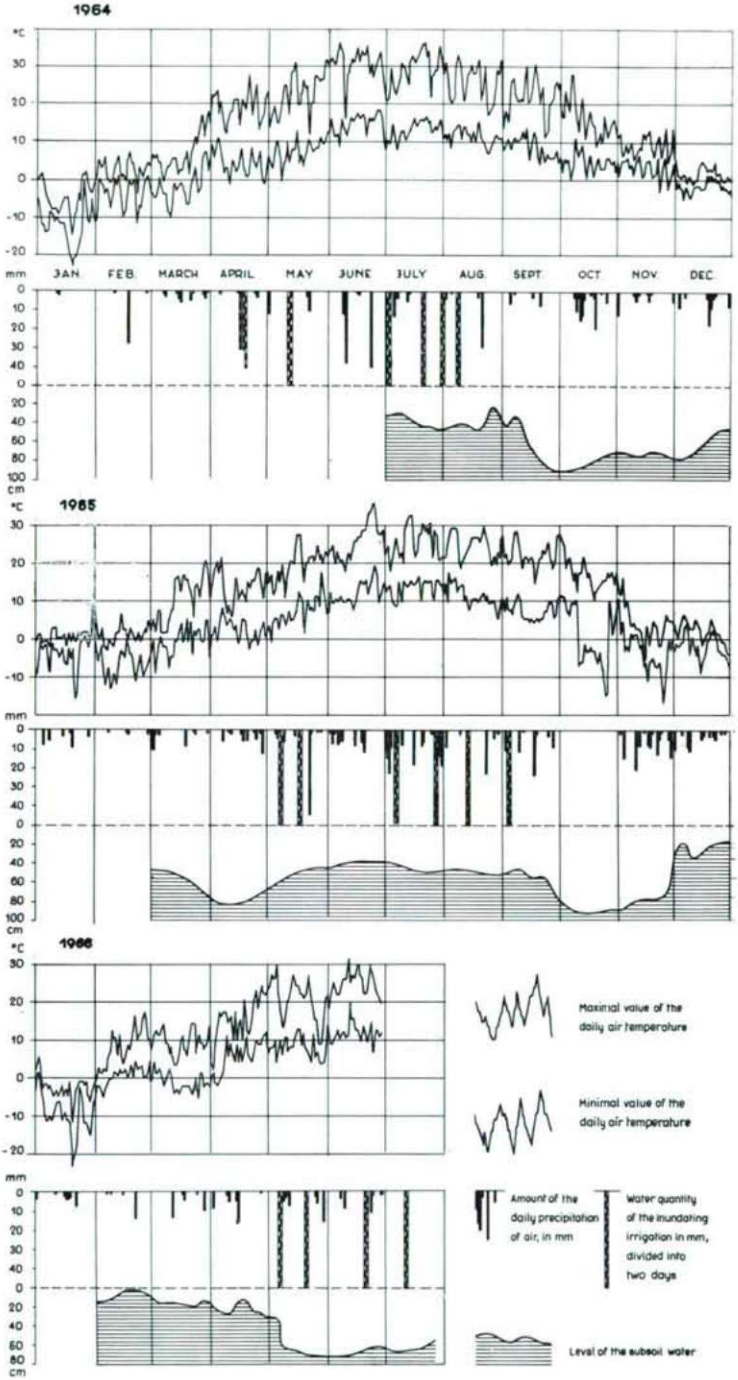
(1) $a_0\ b_0$	(5) $a_1\ b_0$	(9) $a_2\ b_0$
(2) $a_0\ b_1$	(6) $a_1\ b_1$	(10) $a_2\ b_1$
(3) $a_0\ b_2$	(7) $a_1\ b_2$	(11) $a_2\ b_2$
(4) $a_0\ b_3$	(8) $a_1\ b_3$	(12) $a_2\ b_3$

Soil-amelioration (Autumn 1963)	Fertilization (repeated yearly)
a_0 = unameliorated	b_0 = unfertilized
a_1 = 27 q $CaSO_4 \cdot 2H_2O$/ha	b_1 = 90 kg P_2O_5/ha
a_2 = 67 q $CaSO_4 \cdot 2H_2O$/ha	b_2 = 74 kg $NH_4 \cdot NO_3$/ha
	b_3 = 90 kg P_2O_5+74 kg $NH_4 \cdot NO_3$/ha

At setting the experiment, in August 1963, after the original saline meadow of *Lepidio-Puccinellietum asteretosum* type had been broken by a distiller, sulphate of lime and fertilizer doses got into the soil, with a seed mixture composed apropriately to the subject.

The alkali plains in the Danube valley dry up more and more in a natural way or by reclaiming and the salt-concentration of soil increases. For eliminating this harmful effect and for ensuring the water required by the hygrophilous species, we have made possible the intermittent irrigation on the experimental plots by inundation and by surface irrigation. In dry, rainless periods we administered the inundation water 3—4 times in every vegetation cycle,

Fig. 1. Change of temperature of the amount of precipitation, of irrigation water, and of the level of subsoil water during the period of examination.



1964
1965
1966
°C
mm
cm
JAN.
FEB.
MARCH
APRIL
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
Maximal value of the daily air temperature
Minimal value of the daily air temperature
Amount of the daily precipitation of air, in mm
Water quantity of the inundating irrigation in mm, divided into two days
Level of the subsoil water

according to 100 mm atmospheric precipitation. The excess of water not absorbed by the soil (40—60 per cent or so) was drained from the area.

The use of components in a greater number than in routine procedures was justified by the supposed selective influence of the solonchak-solonetz soil where, for the time being, the degree of selection is more or less unknown.

For determining the special amount of seed used for sowing, we kept in mind the probable degree of the concurrence between the species. Some date concerning their influence are published by ARENS (1962). The components are species requiring different croplands and forming different grass levels. Their distribution is as follows:

	Lower	Middle	Upper	Seed	
	grass level			kg/ha	per cent
Molinietalia and *Arrhenatheretea* species:					
Arrhenatherum elatius			0	5,91	17,0
Phleum pratense			0	0,06	2,8
Trifolium hybridum		0		0,70	2,0
Lotus corniculatus	0			3,39	9,7
Agrostion species:					
Festuca pratensis			0	2,35	6,7
Alopecurus pratensis			0	1,22	3,5
Beckmannion species:					
Beckmannia eruciformis			0	2,61	7,5
Bromion and *Festuco-Brometea* species:					
Poa angustifolia		0		2,26	6,5
Bromus inermis			0	8,34	24,0
Species indifferent to cultivation and association:					
Lolium perenne		0		1,51	4,3
Medicago sativa		0		3,75	10,8
Festuca rubra	0			1,82	5,2

The daily precipitation distribution of the firat three years of the experimental priod, as well the dates and amounts of irrigations and the change of maximum-minimum values of the air temperature as measured on the grass level ar demonstrated by Fig. 1 together with the level curve of subsoil water.

The qualitative and quantitative changes of the association conditions of experimental plots were fixed two times in each vegetation period, in the Spring and Autumn aspects, immediately before mowing time, in the form of phytocenologic surveys, giving the values of D-scale in percentage.

The mean height of species was ascertained, as well, and by the help of it also the calculation of the supersoil production amount could be carried out for every species. We can find general productionecologic examinations at GORHAM and PEARSAL (1956); meadow production examination results by phytocenologic surveys in BALÁZS's papers (1944., 1949), as well in the works of IVINS (1959) and SEARS (1962). And data concerning the plant ecologic examinations of their productivity and quality are published by UBRIZSY (1943).

Our method employed in this area — which is simpler and can be carried out faster — was demonstrated at the Symposium of the International Society for Plant Geography and Ecology in 1966 and applied at a number of similar examinations of ours, giving good connections between the total overground production amount of plots and the weight of dry-hay.

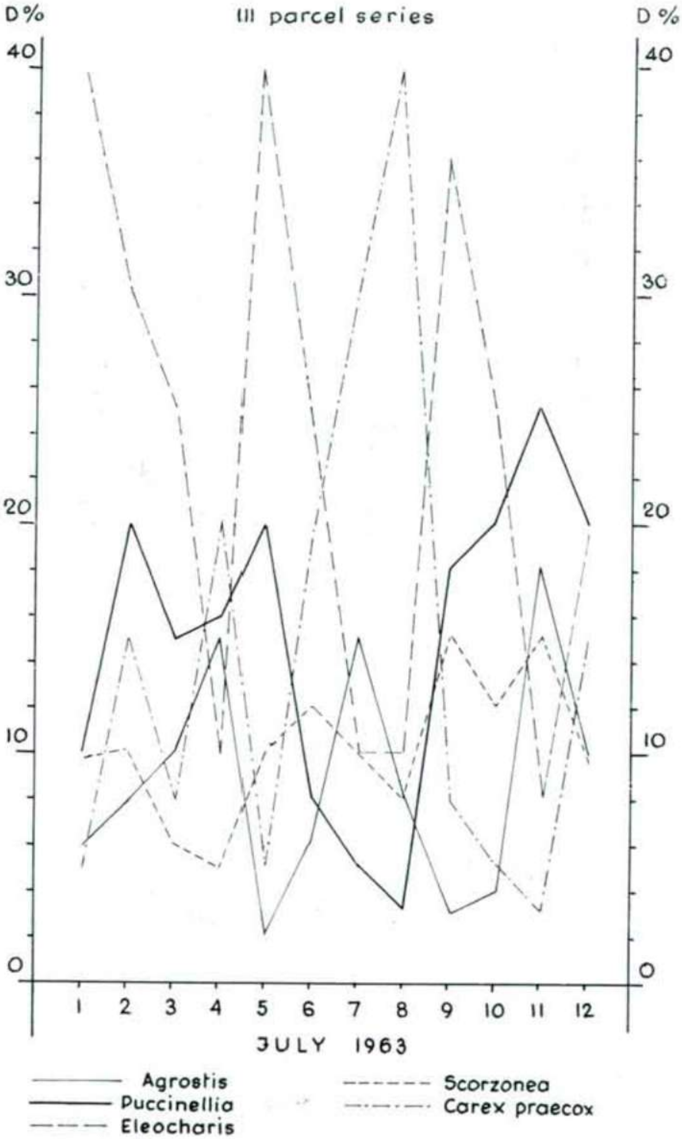


Fig. 2. Change of dominance percentage of major species of the original plant association in parcel series III (parcels 1—12) of the experimental area.

Original vegetation of the experimental plots

For making clear and evaluating the connections of the synecologic conditions of meadow associations, their detailed phytocenologic croplandecologic analyses and examinations are indispensable. We obtain some data for their comprehensive knowledge from KLAPP (1951); HUNDT (1958); MARGIT KOVÁCS (1958), VICHEREK (1962), and — concerning the area between Danube and Tisza — from BODROGKÖZY (1960).

The results of the synecologic analyses of the saline meadows in the Danube valley are going to be published in the next future, the most extensive association of their beloise-eroded saline plains being *Lepidio-Puccinellietum.* They are cultivated here and there with inundating irrigation for growing their yield. Their solonchak-solonetz soils got thereby more and more disalkalized, their Na_2CO_3 content decreased. The typical form of the original *Puccinellia* meadow grew richer with mildly halophytic hygrophilous species. Thus its species combination was entered by *Agrostis alba, Eleocharis uniglumis, Aster tripolium ssp. pannonicus, Rorippa silvestris ssp. kerneri.* This periodic inundation, however, could not prevent thoroughly the single xerophilous halophytae from occuring, and the *Hordeum hystrix Scorvonera cana* was even multiplied considerably. An interesting phenomenon is the sporadic multiplication of *Carex praecox* having an extremely high ecologic adaptability; its dominance values can reach even 40 per cent.

Our experimental plots happenned to lie similarely in such saline meadow sections inundated for a long time. Their plant substance was rather uniform in a larger area and, at the beginning of the experiments, the original vegetation could be considered as a withering version of *Lepidio-Puccinellietum limosae asteretosum,* forming, at any rate, very extensive stocks in the Danube valley and being more and more a burdon on the agricultural practice.

The changes of dominance and quantitative output of the original vegetation in the single plots are demonstrated on the original species combinations of repetition III of the experimental series, divided according to plots (Fig. 2).

Results of the first vegetation year:

The first cenologic surveying of our experimental plots could take place in the Spring aspect after plantation, i. e., in June 1964.

From the four experimental series, a survey and measurements of mean height of repetition I and III were carried out according to plots and species.

(1) As the exact establishment of the springing and strengthened species and even the measurement of their dominance values, could be performed, we got the surprising results, unexpected for us, that 75 per cent of the planted species occurred in the species combinations of plots in spite of the saline soil conditions.

(2) In the frist vegetation year the following characteristics can be established:

(a) There couldn't be discovered, as yet, any considerable difference between the plots ameliorated by a fertilizer and the control plots which were not fertilized. Therefore, we treat in the following only of the evaluation of changes that occurred as a consequence of the fertilizer doses (Tab. I).

As a result of the breaking up, some of the species of the original meadow association got back among the sowed species, a leading role, however, could be obtained first of all by the ephemerous halophytic *Puccinellietalia* elements like *Hordeum hystrix, Matricaria chamomilla var. salina, Cerastium dubium,* and also the degree of return of *Puccinellia limosa* is considerable; the output of its production is 6—12 at a 5—10 per cent cover.

(b) From the sowed glycophytae the association-indifferent *Lolium perenne* showed up the highest overlay value; its quantitative output is nearly always over 10. Under saline conditions a special interest may be aroused by the occurence of *Arrhenatherum elatius* whose natural meadow associations were examined by SCHNEIDER (1954), and its ecologic borders were treated of by APERDANNIER (1959). From the *Papilionaceae* species the values of the *Molinietalia* elements, of *Trifolium hybridum* and *Lotus corniculatus* were surpassed by the values of *Medicago sativa* at the beginning.

(3) (a) On plots fertilized with P_2O_5 (90 kg/ha), from the grass species first of all *Lolium perenne* was influenced considerably, showing a 100 per cent increase compared with unfertilized plots considering both the dominance and the quantitative output. If influenced by Phosp-

TABLE I

Unfertilized parcels June 3rd 1964.

Fertilizer and its amount:	∅				$CaSO_4 \cdot 2H_2O$							
					27 q/ha				67 q/ha			
Number of parcel series:	I.		III.		I.		III.		I.		III.	
Number of all species:	17		17		14		15		15		11	
Dominance and production amount:	%	P	%	P	%	P	%	P	%	P	%	P
Puccinellion and Puccinellietalia species:												
H Puccinellia limosa	6	6,9	8	9,6	5	5,8	8	11,6	8	9,8	10	12,3
Th Hordeum hystrix	15	5,2	15	7,2	10	3,4	20	7,6	10	3,0	10	3,4
Th Cerastium dubium	25	8,7	5	1,4	15	4,9	5	1,5	10	2,8	2	0,6
Th Matricaria chamomilla var. salina	18	2,7	12	2,0	10	1,5	18	3,4	17	3,6	10	2,0
Festucion pseudovinae species:												
H Scorzonera cana	0,5	0,1	0,5	0,2	.	.	.	.	0,5	0,1	.	.
Agrostion species:												
H Festuca pratensis	1	1,7	1	1,6	2	3,5	1	1,8	3	4,9	3	5,2
H Alopecurus pratensis	.	.	1	1,7	0,5	0,8	1	1,7	0,5	0,8	.	.
Th Ranunculus sardous	0,2	0,5	.	.	.	.	0,5	1,4	.	.	.	.
H Agrostis alba	1	1,1	2	2,5	.	.	.	.	.	.	.	.
Molinietalia and Arrhenatheretea species.												
H Trifolium hybridum	4	2,3	2	1,1	2	1,1	1	0,6	1	0,6	1	0,5
H Lotus corniculatus	2	1	1,5	0,7	0,5	0,2	0,5	0,2	0,5	0,2	1	0,5
H Arrhenatherum elatius	3	4,1	10	1,4	2	2,6	5	6,2	6	8,0	6	8,2
Bromion-, Festuco-Brometea species:												
H Bromus inermis	0,5	8,0	1	1,6	0,5	2,0	0,5	1,8	0,5	0,7	.	.
H Poa angustifolia	0,5	0,5	0,5	0,6	1	1,2	0,5	0,6	1	1,2	1	1,2
Th Bromus mollis	1	1,2	1	1,3	.	.	1	1,2	.	.	.	.
Association-indifferent species:												
H Medicago sativa	4	1,7	3	1,4	5	1,0	1	0,4	2	0,9	2	1,0
Th Lolium perenne	10	10,3	15	17,2	10	9,2	15	15,0	10	10,7	15	14,4
Th Polygonum aviculare	0,5	.	1	0,1	1	0,1	.	.	1,5	0,2	.	.

phorus, also the *Arrhenatherum* continued increasing its advantage. At the same time, the cover of the thereophytic *Puccinelietalia* elements, first of all that of the species *Matricaria chamomilla v. salina* and *Cerastium dubium* decreased in a considerable degree — while their number did increase with the *Atriplex litoralis* and *Myosurus minimus* occurring thread by thread. *Hordeum hystrix* is, however, an exception.

From the *Papilionaceae* we have expected more considerable advance, however, only *Trifolium hybridum* demonstrated some increase concerning the D percentage. Concerning the effects of Phosphorus-doses on the *Trifolium* species we may, anyway, find some recent data at GERVAIS (1960), and- in grass papilionaceae combination- at HUNG and WAGNER (1963).

(b) The upper grass level of the phosphorus-treated plots of the produced hayfield was et most still open in the Spring aspect of the first year. *Arrhenatherum* prevailed. The highest closing value was reached by the middle grass level, its dominating species being *Lolium perenne, Puccinellia limosa, Trifolium hybridum.* The lower grass level got under the dominance of *Hordeum hystrix* (Tables II, III).

(4) The influence of NH_4NO_3 (174 kg/ha) is advantageus first of all from the point of view of grass species; especially in case of *Festuca pratensis* whose development was investigated by SEREBYAKOVA (1962). While hardly any P-effect could be demonstrated on it in the first vegetation year, after influenced by N, the percentage of D and the value of quantitative output grew double, on the average.

(b) The species of the produced meadow association demonstrated an increased closing in al the three grass levels as a result of nitrogen. The question whether the prevalence or withdrawal of the single species is influenced more by the effect of fertilizer doses or by the conditions of illumination influenced by the closing (SPEIDEL 1966) or rather by the increasing struggle for life of species can hardly be answered exactly, and we must not forget the selective effect of the special physical and chemical influence of the soil, either.

(c) For characterizing the single grass levels, we must ascertain that already in the first vegetation year sharp differences could be seen concerning both the dominance and quantitative output, to the advantage of nitrogen treatment, opposite to both the control and the P-treated plots. The 40—50 per cent closing of the upper grass level is a result of the summing up of dominance values of *Arrhenatherum elatius* (20—30 p. c.), *Festuca pratensis* (5—12 p. c.), and *Bromus inermis* (3—7. p. c.). We expected the last mentioned species in the formation of the upper level to get the leadership as it was for years the dominant species of the level in the solonetz soil H o r t o b á g y as a result of fertilizer doses (BODROGKÖZY 1962), and 24 per cent (8,34 kg/ha) of the grain sowed in the plots was obtained from *Bromus inermis.*

The dominant species of the middle grass level was *Lolium perenne,* with a further considerable expansion although yielding only, 4,6 per cent of the sown grass seed. Beside it is *Puccinellia limosa,* without any major change. The *Papilionaceae* of that level sufferred an extremely great regression; they survived hardly, only thread by thread, rather spindled for want of water.

The species of the lower grass level were obtained, also henceforward, from the ephemerous species of *Puccinellietalia* elements; first of all *Hordeum hystrix* and *Cerastium dubium* are rather considerable, at which the nitrogen effect, independently of the increased overshadowing, caused a considerable expansion. The values of *Matricaria* have not changed considerably (Fig. 3).

TABLE II

P_2O_5 (90 kg/ha) treated parcels June 3rd 1964.

Fertilizer and its amount:	∅				$CaSO_4 \cdot 2H_2O$							
					27 q/ha				67 q/ha			
Number of parcel series:	I.		III.		I.		III.		I.		III.	
Number of all species:	15		16		13		14		14		13	
Dominance and production amount:	%	P	%	P	%	P	%	P	%	P	%	P
Puccinellion- and Puccinellietalia species:												
H Puccinellia limosa	8	9,1	5	5,8	10	11,9	8	10,5	5	5,8	5	0,6
Th Hordeum hystrix	10	6,9	8	4,6	12	7,4	10	5,8	15	8,6	5	3,0
Th Cerastium dubium												
Th Matricaria chamomilla var. salina	2	0,7	1	0,3	5	1,4	1	0,3	3	1,1		
Th Atriplex litoralis		0,5							1	0,3		
Th Myosurus minimus	0,5	0,3										
Festucion pseudovinae species:												
H Scorzonera cana					0,5	0,2						
Beckmannion species:												
H Beckmannia eruciformis			1	1,2	1	1,2	1	1,2			1	1,2
H Rorippa silvestris ssp. kerneri	0,5	1,4	0,5	1,4								
Agrostion species:												
H Festuca pratensis	4	3,8	4	11,2	3	3,5	3	3,7	5	5,8	2	1,9
H Alopecurus pratensis			2									
H Agrosis alba	1	0,8		1,7			2	1,5	1	0,2	1	0,8
Molinietalia and Arrhenatheretea species:												
H Trifolium hybridum	3	0,9	5	1,7	2	0,7	2	0,6	3	0,9	3	1,0
H Lotus corniculatus	1	0,3	3	0,3	1	0,3	1	0,3	1	0,3	1	0,3
H Arrhenatherum elatius	10	15,3	8	11,5	16	23,6	8	11,1	10	15,3	8	11,0
H Phleum pratense	1,5	12,9	2	1,5			2	1,6	1	0,7	2	1,6
Bromion and Festuco-Brometea species:												
H Bromus inermis	1	1,3	4	4,6	1	1,2	1	1,3	1	1,1	2	1,3
Th Bromus mollis	0,5	0,4	1	1,0	1	0,6					0,5	0,3
H Poa angustifolia			1	1,3			1	1,2				
Association-indifferent species:												
H Medicago sativa	3	1,4	3	1,4	5	1,1	2	0,1	2	0,1	1	0,4
H Lolium perenne	30	34,5	15	17,3	25	27,8	20	23,8	30	32,2	20	24,9
Th Polygonum aviculare									0,5	—		

TABLE III $NH_4 \cdot NO_3$ (174 kg N/ha) treated parcels June 3rd 1964.

Fertilizer and its amount	∅				Ca SO₄ · 2 H₂O 27 q/ha				Ca SO₄ · 2 H₂O 67 q/ha			
Number of parcel series:	I.		III.		I.		III.		I.		III.	
Number of all species:	14		12		12		16		12		17	
Dominance and production amount:	%	P	%	P	%	P	%	P	%	P	%	P
Puccinellion Puccinellietalia species:												
H Puccinellia limosa	10	13,8	8	10,7	8	1,2	8	10,7	8	11,0	5	6,7
Th Hordeum hystrix	5	3,8	12	9,7	13	10,0	12	9,9	15	12,0	8	6,1
Th Cerastium dubium	5	1,9	10	4,2	12	5,0	10	4,4	3	1,2	5	1,9
Th Matricaria chamomilla	3	0,6	5	0,1	5	0,1	1	0,3			2	0,6
Th Atriplex litoralis	·	·	2	0,5	·	·	2	0,7	·	·	1	0,3
Festucion pseudovinae species:												
H Scorzonera cana	·	·	·	·	0,5	0,1	·	·	0,5	0,1	·	·
Beckmannion species:												
H Beckmannia eruciformis	3	4,0	·	·	2	2,7	1	1,3	1	1,4	1	1,4
Agrostion species:												
H Festuca pratensis	10	13,4	8	10,0	6	8,0	9	12,4	8	11,2	5	6,7
H Alopecurus pratensis	3	4,3	2	2,9	2	2,9	3	4,1	3	4,0	4	5,5
H Agrostis alba	·	·	·	·	·	·	1	1,1	·	·	1	1,1
Molinietalia and Arrhenatheretea species:												
H Arrhenatherum elatius	20	3,4	24	42,3	25	43,1	20	3,2	30	52,9	25	43,1
H Phleum pratense	2	2,5	·	·	·	·	1	1,2	3	3,4	2	2,5
H Trifolium hybridum	·	·	0,5	0,1	·	·	·	·	·	·	·	·
H Lotus corniculatus	·	·	·	·	·	·	0,5	0,1	·	·	0,5	0,1
Bromion and Festuco-Brometea species:												
H Bromus inermis	6	7,5	3	3,7	5	5,9	6	7,5	6	7,7	5	6,2
H Poa angustifolia	1	1,2	·	·	1	1,2	·	·	·	·	·	·
Th Bromus mollis	1	1,2	·	·	·	·	·	·	1	1,2	1	1,2
Association indifferent species:												
H Lolium perenne	30	37,4	25	3,4	20	27,6	22	27,5	20	28,8	30	39,1
H Medicago sativa	·	·	·	·	·	·	0,5	0,2	·	·	0,5	0,2
Th Polygonum aviculare	1	0,1	2	0,2	·	·	1	0,1	·	·	2	0,2

(5) (a) In the first year of vegetation, the double-treated (P + N) plots showed up meadow-association conditions similar to those treated with nitrogen. At some species components, however, some differences could be observed that required consideration. Thus, inside the double treatment, and concerning the demand on phosphorus, it seems so already in the first phase of experiments that the original P-content of soil is enough for the undisturbed development of *Festuca pratensis,* and a further P-amount is of negative effect in consideration of both the covering percentage and the quantitative output (Fig. 3). On the other hand, in case of *Papilionaceae* the N of the double treatment exerts a checking effect.

(b) The influence of P+N—treatment on the grass levels of the produced meadow association manifested itself first of all in the more and more increased closing: the upper level may reach 50—60 and even 70 per cent on the average. From its grass species *Arrhenatherum* keeps leading henceforward, too; the other species don't differ considerably from the solo—N—treated plots.

From the species of the middle level, the *Papilionaceae* have got some advantage compared with the former ones, and also the covering percentage of *Lolium perenne* increased.

Hordeum hystrix shows a further expansion, as influenced by the double fertilizer doses in its lower grass level, altough the degree of overshadowing has continued increasing. It can reach even a 15—20 per cent covering in some plots.

(6) (a) In the Autumn aspect, the differences between the treatments may somewhat grow indistinct, and the differences in Tables concerning the species combinations depend mainly upon the N—treatment. From the levels, the closing of the upper grass level has decreased to be 15—20 per cent; at the same time, *Lolium perenne,* dominating in the middle level, is of a 50—55 per cent cover.

(b) The P—effect is the most intensive from *Papilionaceae* at the *Trifolium hybridum* that springs the fastest after the June mowing, and may reach a 5—8 per cent cover at the end of September, as a result of the propitious light conditions. At the same time, it showed a 3—6 per cent D—value in control plots. *Medicago sativa* has not reached, even with *Lotus corniculatus* together, the 1 per cent coverage averages.

In the untreated and solo—P—treated plots, from the introduced *Puccinellietalia* species, the characteristics of the Autumn aspect, *Aster tripolium ssp. pannonicus,* as well *Artiplex litoralis* have demonstrated a higher coverage value.

Changes taking place in 1965

(1) (a) C l i m a t e : Meadow association in alkali soils and their climates having a close interdependence, it is right if we evaluate the climatic data measured on the grass level, as well. The first part of the vegetation year was favourable for the planted *Agrostion* and *Molinietalia* representatives of our meadow association. From March the climate was cooler, more uniformly rainy than in the former years, decreasing the concentration of soil salts, influenced also by the irrigation. (Fig. 1)

(b) The change of the subsoil level was also in that period of positive effect. The uniform distribution of precipitation, resulted from lacking of a rainfall

TABLE IV

Wet extract

In each cell the upper value (above the line) is printed before the "/" and the lower value after it.

Depth in cm	Ca^{++}	Na^{+}	K^{+}	Mg^{++}	Amount of kations	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}	Amount of anions	Kation + anion mg/100 g
	mg equivalent / mg 100 g					mg equivalent / mg 100 g					
Unameliorated											
0—10	0,29 / 5,81	2,44 / 56,11	0,03 / 1,17	0,47 / 5,71	3,23 / 68,80	0,04 / 1,20	2,56 / 156,21	0,22 / 7,80	0,30 / 14,41	3,12 / 179,62	248,42
10—20	0,10 / 2,00	3,85 / 88,54	0,03 / 1,17	0,08 / 0,97	4,06 / 92,68	0,10 / 3,00	3,19 / 194,65	0,25 / 8,86	0,65 / 31,22	4,19 / 237,73	330,41
20—30	0,10 / 2,00	3,29 / 75,66	0,02 / 0,78	0,16 / 1,95	3,57 / 80,39	0,30 / 9,00	2,49 / 151,93	0,24 / 8,51	0,73 / 35,06	3,76 / 204,50	284,89
30—50	0,07 / 1,40	2,93 / 67,38	0,02 / 0,78	0,01 / 0,12	3,03 / 69,68	0,74 / 22,20	1,76 / 107,39	0,16 / 5,67	0,42 / 20,17	3,08 / 155,43	225,11
50—70	0,06 / 1,20	2,27 / 52,20	0,02 / 0,78	0,09 / 1,09	2,44 / 55,27	0,44 / 13,20	1,54 / 93,97	0,21 / 7,45	0,36 / 17,29	2,55 / 131,91	187,18
70—90	0,04 / 0,80	1,47 / 33,81	0,02 / 0,78	0,09 / 1,09	1,62 / 36,48	0,18 / 5,40	1,11 / 67,73	0,16 / 5,67	0,31 / 14,89	1,76 / 93,69	130,17
Dressed with sulphate of lime (a1)											
0—10	0,77 / 15,43	1,72 / 39,55	0,02 / 0,78	0,36 / 4,38	2,87 / 60,14	— / —	2,40 / 146,44	0,17 / 6,03	0,34 / 16,33	2,91 / 168,80	228,94
10—20	0,07 / 1,40	3,36 / 77,27	0,04 / 1,56	0,27 / 3,28	3,74 / 83,51	0,30 / 9,00	2,22 / 135,46	0,32 / 11,35	0,88 / 42,27	3,72 / 198,08	281,59
20—30	0,06 / 1,20	3,50 / 80,49	0,03 / 1,17	0,08 / 0,97	3,67 / 83,83	0,26 / 7,80	2,48 / 151,32	0,24 / 8,51	0,70 / 33,62	3,68 / 201,25	285,08
30—50	0,06 / 1,20	2,96 / 68,07	0,03 / 1,17	0,17 / 2,07	3,22 / 72,51	0,34 / 10,20	2,09 / 127,53	0,19 / 6,74	0,62 / 29,78	3,24 / 174,25	246,76
50—70	0,04 / 0,80	2,21 / 50,82	0,04 / 1,56	0,01 / 0,12	2,30 / 53,30	0,50 / 15,00	1,29 / 78,71	0,26 / 9,22	0,44 / 21,13	2,49 / 124,06	177,36
70—90	0,04 / 0,80	1,06 / 24,38	0,02 / 0,78	0,05 / 0,61	1,17 / 26,57	— / —	0,95 / 57,97	0,15 / 5,32	0,21 / 10,09	1,31 / 73,38	99,95
Dressed with sulphate of lime (a2)											
0—10	1,04 / 20,84	1,28 / 29,44	0,04 / 1,56	0,48 / 5,84	2,84 / 57,68	— / —	1,67 / 101,90	0,15 / 5,32	1,07 / 51,39	2,89 / 158,61	216,29
10—20	0,11 / 2,20	3,91 / 89,92	0,04 / 1,56	0,05 / 0,61	4,11 / 94,29	— / —	2,97 / 181,22	0,19 / 6,74	1,00 / 48,03	4,16 / 235,99	330,28
20—30	0,07 / 1,40	2,91 / 66,92	0,03 / 0,17	0,06 / 0,73	3,07 / 70,22	0,42 / 12,60	1,76 / 107,39	0,20 / 7,09	0,78 / 37,46	3,16 / 164,54	234,76
30—50	0,07 / 1,40	2,57 / 59,10	0,03 / 1,17	0,11 / 1,34	2,78 / 63,01	0,19 / 5,70	1,89 / 115,32	0,17 / 6,03	0,53 / 25,46	2,78 / 152,51	215,52
50—70	0,07 / 1,40	2,26 / 51,97	0,03 / 1,17	0,01 / 0,12	2,37 / 54,66	— / —	1,56 / 95,19	0,25 / 8,86	0,44 / 21,13	2,25 / 125,18	179,84
70—90	0,07 / 1,40	1,73 / 39,78	0,02 / 0,78	0,01 / 0,12	1,83 / 42,08	0,44 / 13,20	0,95 / 57,97	0,25 / 8,86	0,30 / 14,41	1,94 / 94,44	136,52

surpassing 10 mm, produced a relatively deep-lying subsoil waterlevel. This was changed only by the major precipitation of May-end and by the inundating irrigations; as a consequence of these, the soilwater level increased from 84 to 48 and later 42 cm, and decreased only in the Autumn period, in middle of October, to 90 cm again (Fig. 1).

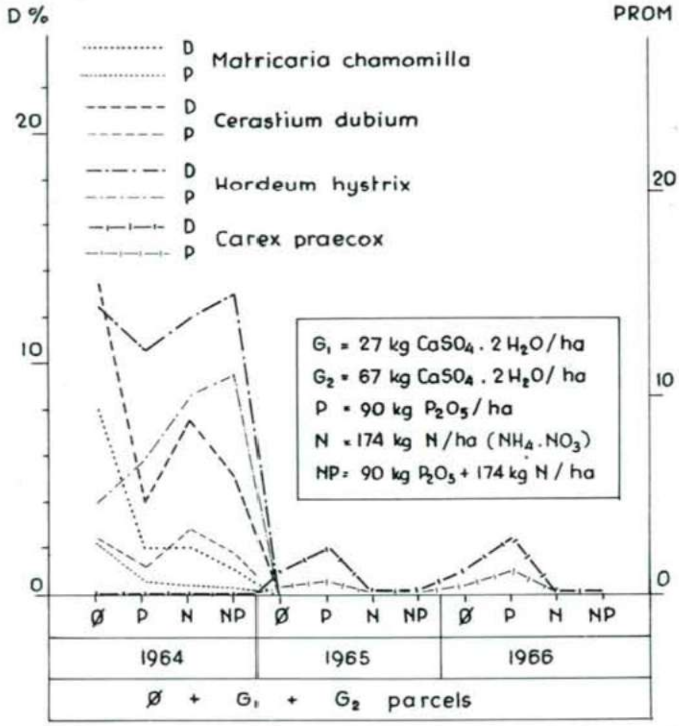


Fig. 3. Change of the dominance percentage and of the amount of surface production of some resettled species, as a result of different fertilizer doses.

Although the most roots of the meadow plant species in alkali soils take place in the upper 10 cm (HARMATI 1959), the high subsoil waters have a definitely positive effect on the development of the plant associations of our plots as well as under other, glycophilous cropland conditions (KLAPP 1954). That positive effect appears first of all in influencing the amount of soil moisture in a positive direction. This effect was examined by VAN'T WOULT and BESSEL (1955) in connection with the fertility of *Trifolium*. DANCAU (1962) reports some data connected with the water household of the plant species of meadows.

(2) S o i l. For clearing up what a soilchemical transforming effect the plastering may produce in the second vegetation year, the patterns of the different soil profiles were subjected to detailed laboratory examinations. According to the analysis of the water extracts, in Na_2CO_3 the Na ions don't exceed the 4 mg equivalent counted on 100 g soil in the unreclaimed plots in an accumulation level near the soil. In the upper 10 cm, woven by roots the most intensively, the

conditions are more propitious. Influenced by gypsum treatment, the amount of Na ions decreased therefore 1/3 in the layers of the upper surface, in a major dose 1/2.

The influence of the changeable Na on the species *Trifolium* and *Medicago* was examined by BERNSTEIN and PEARSON (1956); that of soil reaction and fertilizer supply on the meadow associations by BOECKER (1954). For the determination of Na-ions bound in the absorption complex we have used HERKE's method of determination instead of MEHLICH's routine procedure. Accordingly there was a major amelioration first of all in case of higher dose gypsum administration. Further details are given in Table IV. The connections between plant associations and soil conditions of natural meadows of glycophylous type are known on the basis of the examinations of BOER (1958) and MARSCHALL (1958). The alkaline differences between our plots reclaimed in different degrees, however, did not cause any major differences in the species combinations in the first two vegetation years if the inundation irrigation and proper fertilizers were ensured.

(3) Vegetation. In the second vegetation year the experimental plots showed a considerable change concerning their species combination. It is obvious that the ephemerous halophytic *Puccinellietalia* elements, multiplied as a result of the breaking, fell fully into the background, while some sown species like *Arrhenatherum elatius* suffered a larger decrease, and other ones like *Poa angustifolia, Festuca pratensis* gained uniformly, and *Lolium perenne* suddenly, ground.

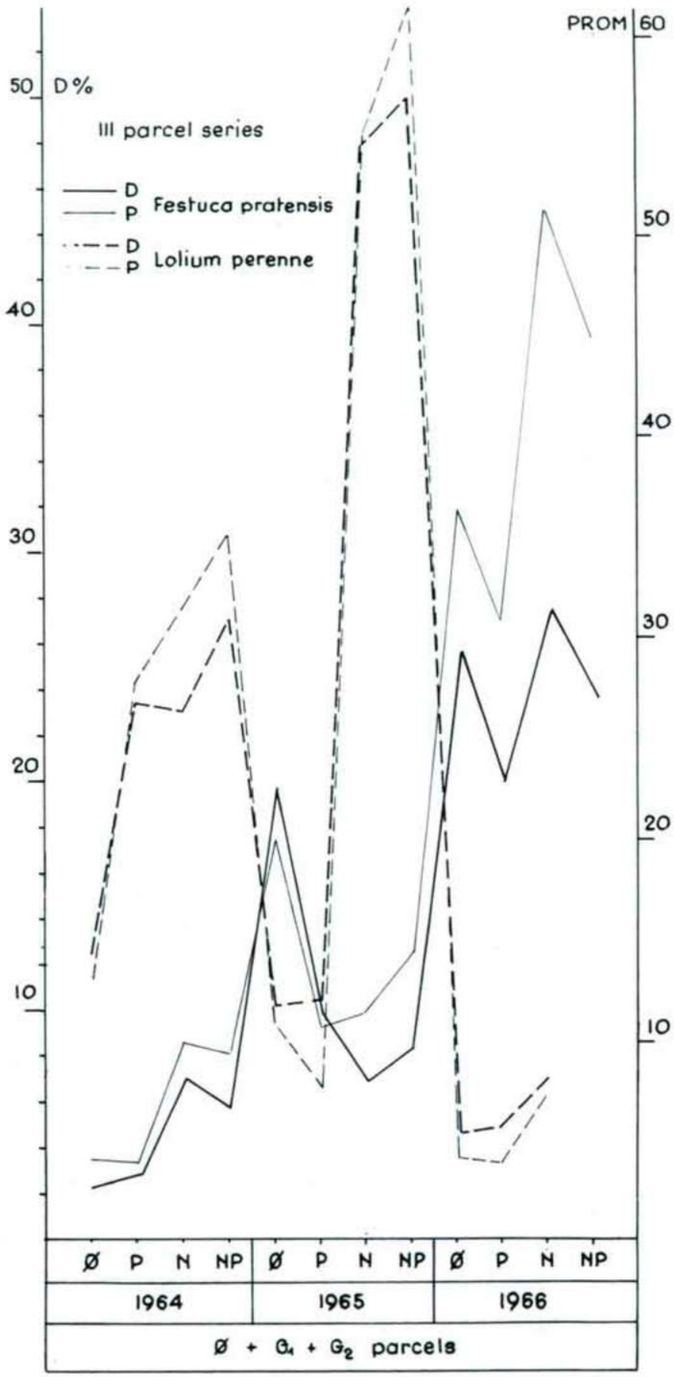
(a) The changes of plots of the formed meadow associations in respect of the grass level may be summarized as follows: on plots getting no fertilizer doses the groups of soil elements behaved differently on the basis of the means of the quadruple repetitions. The quantitative outset of *Lolium perenne* that could not get suitable fertilizers, first of all N, did not reach 10, being thus lower than it was in control plots of the beginning year. This may be attributed mainly to the increasing spread of *Festuca pratensis.*

Also some *Molinietalia* elements gain a considerable ground; the sudden advance of *Trifolium hybridum* observed in control conditions is especially remarkable; although the theree sown *Papilionaceae* ran to 21 per cent of the total seed used for sowing and the *Trifolium hybridum* only 2 per cent, its covering value being between 2 to 12 per cent. At the same time *Lotus corniculatus* has only a D—value of 0,5 to 2 per cent, and *Medicago sativa* occurs possibly only thread by thread.

The ecotype of bastard trefoil [Swedish clover] used by us is, unfortunately, not resistant enough to *Erysiphe* and its foliage is highly damaged especially in the Indian summer period.

(b) As a result of phosphorus treatment, a great number of the settled grass species have demonstrated a considerable recession, striking the eve particulary in case of *Festuca pratensis. Agrostis alba, Poa angustifolia;* in other cases, e. g., at *Lolium perenne,* the change is unimportant. It is even more obvious that also *Trifolium hybridum* demanding P lost ground (Fig. 4). At the same time, from

Fig. 4. Values of the coverage of *Festuca pratensis* and *Lolium perenne* (D) and of th amount of their surface production (P). PROM = ASP.


50
D%
III parcel series
D
P
Festuca pratensis
D
P
Lolium perenne
40
30
20
10
PROM
60
50
40
30
20
10
Ø P N NP Ø P N NP Ø P N NP
1964
1965
1966
Ø + G₁ + G₂ parcels

the introduced species, the *Carex praecox* occurs which, forming a dense rhyzoid-system, may be considered as a *Festuco-Brometea* species. Although its dominance value is low, its root concurrence plays a considerable role in forming the species combinations of the phosphorus-treated plots. The problem of competitions between the plant substances is treated of by BAEUMMER, BORNKAMM (1963); SPEIDEL (1966), as well.

The closing values of their grass levels are on a rather low degree. *Festuca pratensis,* dominant in the upper level, ensures a closing value of 6—12 per cent. The situation is better concerning the middle level where the values of the two resettled grass species, *Puccinellia limosa* and *Agrostis alba,* are raised by the setled *Poa angustifolia, Lolium perenne* and *Trifolium hybridum,* thus the value of closing of this level is 30—35 per cent or so. The lower grass level was represented by *Carex praecox* and the pushed off *Lotus corniculatus* with a rather low closing value, as the therophytic *Puccinellietalia* elements had disappeared and so did among them the *Hordeum hystrix* so widely spread in the first vegetation period.

(c) In the nitrogen-treated plots there took place highly important changes in covering and quantitative output as compared with those observed in the first vegetation year. There is remarkable first of all the nitrogen utilization of *Lolium perenne* whose quantitative output values have almost redoubled as compared to those of the last year. As influenced by an increasing concurrence, it ousted considerably the more and more efficient *Festuca pratensis* which accomodated very much to the dominant cropland conditions, together with the *Agrostis alba* of similar demand on a cropland. Opposite to it only the *Alopecurus pratensis* and *Poa angustifolia* proved to be competitive. The effect of fertilizers on *Lolium perenne* was, anyway, treated of by BERG (1962), and the association programs of *Lolium* species by VINCEFFY and co-workers (1954).

While the *Agrostion* species maintain their leadership after the spread of *Alopecurus pratensis,* the *Molinietalia,* resp. *Arrhenatheretea* species show a major recession in the Spring aspect of the second vegetation year. The *Papilionaceae* belonging here can hardly be found, mostly thread by thread.

In the upper grass level of these plots the leadership belongs already to *Alopecurus pratensis,* and beside it *Beckmannia eruciformis, Festuca pratensis, Bromus inermis* and *Arrhenatherum elatius* participate with their low covering in the closing degree of about 25—35 per cent only in a slight extent. In the middle level the closing is but of 65—78 per cent as a consequence of the covering percentage of *Poa angustifolia* and *Puccinellia* which are present apart from the mass presence of *Lolium.* Owing to the overshadowing of such a high degree, a lower grass level could not be formed in a continuous form.

(d) The double fertilizer doses of P and N have not brought about any considerable change. The covering percentage of *Lolium perenne* kept on rising. In the relation of grass level a situation similar to the plots with solo Nitrogen could be observed.

(e) In the Autumn aspect the sudden advance of *Trifolium hybridum* in the control and phosphorus-treated plots is the most obvious; it took up in control plots five times, in P-treated ones three times as large areas as in similar periods of the year before. This enormous increase is, however, not connected to the original seed. *Trifolium hybridum* granulating fast after the June mowing attains earlier the state of a recent flowering than other components and its seed-ripening till the period of second mowing is as well ensured as the possibility of its further growth. Although these possibilities are given also in case of *Lotus corniculatus*, its covering percentage has not surpassed 8 per cent even in P-trea-

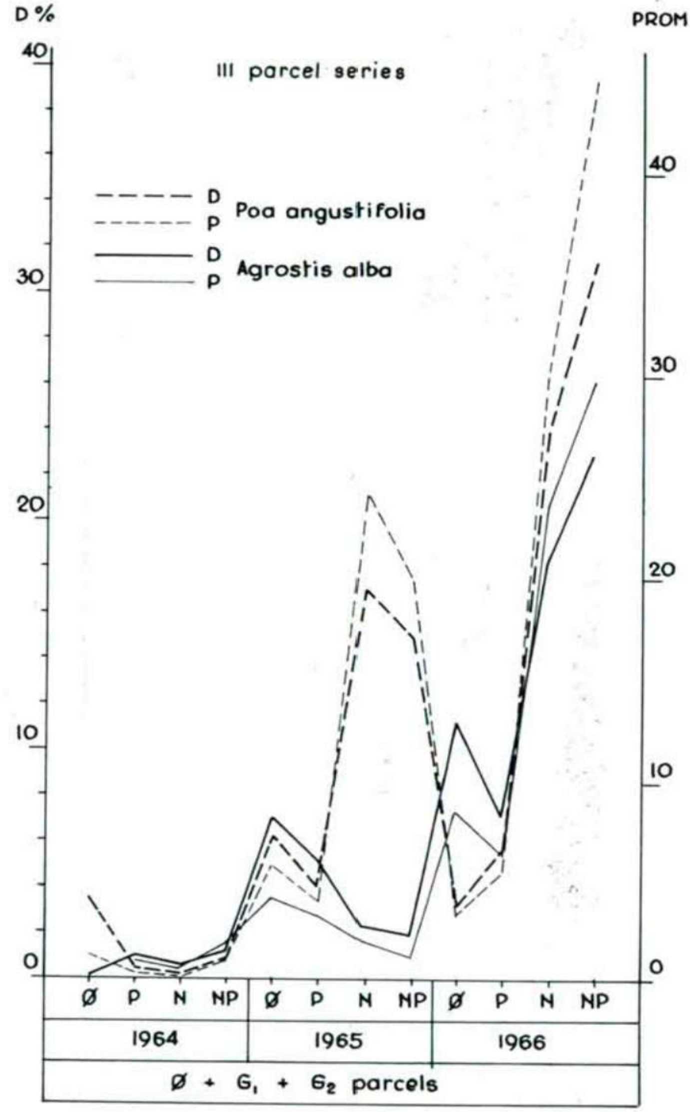


Fig. 5. Change of D and P values (P = PROM = ASP) of the *Poa angustifolia* and *Agrostis alba* during the period of examination.

ted plots. From that we can conclude the obviously good adaptability of *Trifolium hybridum* in a solonchak-solonetz soil of weakly saline surface soil of Danube valley under hygrophilous conditions. At the same time that species occured in the alkaline moorland of Danube valley not more than sporadically, (Fig. 6).

The Autumn aspect of the so produced meadow associations hadn't a major upper and lower grass level even at the end of the second vegetation year. All the more closed is the middle level, the dominant species being also here, the *Lolium perenne*. Its dominance values are, however, often approached by *Poa angustifolia*. That may be considered as a sign of the change in the dominating position of the two species. In P-treated plots the degree of this level-closing reaches, with *Papilionaceae* together, 80—90 per cent.

Results of the third vegetation year.

In the composition of the meadow associations settled in our experimental plots some considerable changes took place in the year 1966.

(1) As to the c l i m a t e, our spring period continues being rainy and rather cool, in contrast to the accustomed lowland climate. In the air layer of the grass level, the maximum of air temperature did not surpass 30 C° even in June, apart from one exception. The more uniform distribution of precipitation was completed by an inundating-irrigation employed twice in May. Even the level of subsoil water of this period is high; it is 30 cm or so on the average, sinking under 60 cm only in May (Fig 1).

As influenced by the favourable meteorological and the consequent soil ecologic events at our meadow associations, a change took place to the advantage of the glycophyta in the area of the settled species. Thus the *Puccinellia* which had, with lesser fluctuations, a 6—10 per cent covering value in the former years, has now suffered a considerable loss of area in relation to *Agrostis alba* similarly resettled. At any rate, its lower dominance values may also be attributed to the cool Spring climate not favourable for it. As a consequence of the undisturbed meadow development, also the therophytic *Puccinellietalia* elements were fully driven back.

(a) In our plots without fertilizers, on the basis of the species combination of earlier years, we have to emphasize two important changes: the considerable recession of *Lolium perenne* and the parallel advance of *Festuca pratensis* in the control plots, resp. the advantage of *Agrostis alba* opposite to *Poa angustifolia*. *Agrostis* figured in the control plots in a similar way in the similar periods of all the three years, the inference being that it has a rather weak competitiveness. *Trifolium hybridum* continues gaining place even in control plots after seed-dropping.

(b) The favourable influence of the phosphorus dose is again repeated at the most kinds of grass. The decline of *Festuca pratensis* and *Agrostis alba*, similar to that in the former year, concerning both covering percentage and quantitative output, is particularly remarkable. It is the most favourable from the point of view of *Trifolium hybridum* and *Lotus corniculatus* belonging to *Molinietalia*

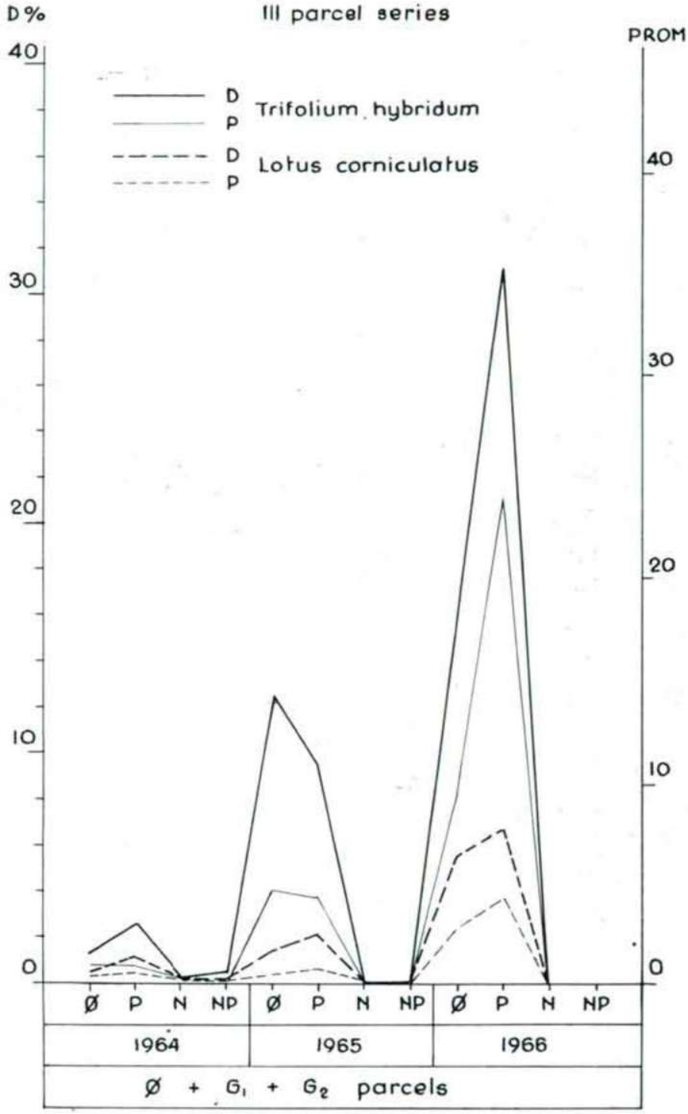


Fig. 6. Changes of D and P values (P = PROM = ASP) of the two *Papilionaceae* species of the association in the culture meadow.

elements whose spreading is still rising, for the time being, in direct ratio to the number of years; the covering percentage of *Trifolium* surpasses 30 per cent, and its quantitative output 35 per cent. On the other hand, *Medicago sativa* disappeared fully even from the P-treated plots.

The P-effect is definitely advantageous to the development of *Carex praecox,* as well, apart from the mentioned *Papilionaceae,* in our experimental tables, without enabling, anyway, a major spread of the *Festuco—Brometea* species in the third year.

(c) In the Nitrogen-treated plots, a major decline of *Lolium perenne* catches the eye, without being able to be prevented even by N-administration. At the same time, we have to reemphasize the sudden increase of the quantitative output of *Festuca pratensis* as compared with the covering percentage. The same may be ascertained also in case of *Poa angustifolia* which employs the N-fertilizer extremely profitably. Its multiplication is obviously high: 25—35 per cent, first of all in the Nitrogen-treated plots (Tab. VI).

It is characteristic of the level of these plots that in their upper grass level *Festuca pratensis* keeps on dominating; also *Alopecurus pratensis* is rather considerable here and there: its increase has, however, not even approach that observed in case of the cultivated meadows set up in the solonetz soils beyond the Tisza (BODROGKÖZY 1962, 1965).

The closing degree of the middle grass level is the highest first of all as a consequence of the prevalence of *Agrostis alba,* resp. *Poa angustifolia.* The opposite formation of the power relations may be explained mainly by the discontinuance of the concurring influence of *Lolium perenne,* measurable by the change of the covering percentage of *Agrostis alba,* as well.

Problem of succession of the ancient covering vegetation. On the plots there could not be observed even an initial state of the original species combinations of the *Lepidio-Puccinellietum asteretosum* which was dominant at the beginning of experiments; later, however, it was broken. As influenced by irrigation and Nitrogen doses, the cenoses of plots may be considered as a cultivated subassociation of *Astero-Agrostetum Poa angustifolia,* as a consequence of the change of cropland conditions, whether or not some fertilizers were applied. In its species combinations the settled and resettled species have the leadership. Even today, these can be observed everywhere in the weakly saline solonchak solonetz soil settled on sand in the moorlands between Danube and Tisza, having a better water supply. Both from point of view of level proportion and from that of output they are standing on a more developed degree than the *Astero-Agrostetum* substances of the croplands of Danube plains with a larger backwater content (Tab. VII).

(d) The double-treated (P+N) plots yielded the highest total quantitative output of the third vegetation year (Fig. V). The influence of the double fertilizer doses can be observed first of all at *Poa angustifolia, Festuca pratensis,* however, showed some recession. This may be explained probably not only by the effect of the power relations of the concurrence but by the for it unfavourable influence of phosphorus, as well, taking place not only in case of the solo P-treatment but also in that of a double treatment.

Their species number, like in the solo-N-treated plots, decreases also here, and their cenoses consist of hardly 6—8 species. Apart from the sown grass species as well from both resettled ones, other settled species can hardly be observed, at most only thread by thread, even in three years after the settlement.

Connection between the total output and the dry hayweight. The spatial distribution of the overground mass of plant substances is such that a great part of the vegetative mass of grasses is concentrated nearer the soil than at the *Papilionaceae*. Thus in the species combinations of *Gramineae* and *Papilionaceae* species a more uniform distribution of output may take place, and their output is greater than that of pure substances (ALEKSEENKO 1958). The sum of the output calculated for species on the basis of dominance values and height averages may only be considered as a real value if it doesn't differ considerably from the values obtained by measurements (dry-hay). For control and easier perspicuity the first mowing dry hay-weight of the single vegetation years are charted according to plots. Drawing the curve of mean values, we have proceeded similarly with the values of the total quantitative output, as well. The connections observed in the Spring aspect of the vegetation year 1966 are demonstrated in Fig. 7.

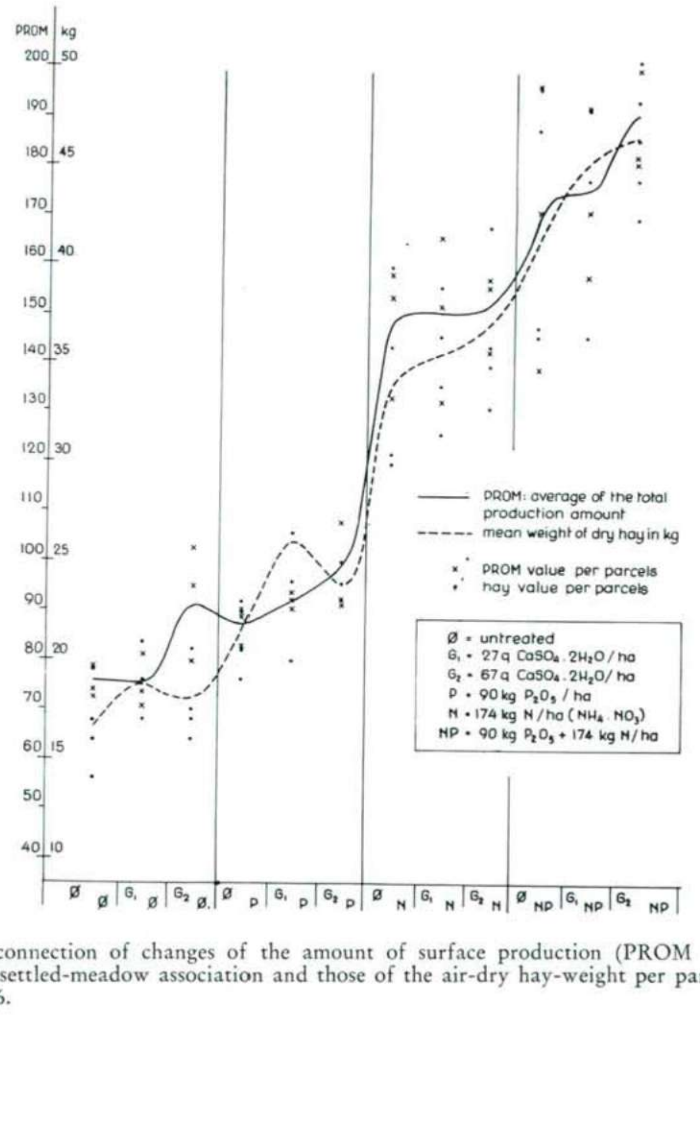


Fig. 7. Interconnection of changes of the amount of surface production (PROM = ASP) of the settled-meadow association and those of the air-dry hay-weight per parcels in June 1966.

TABLE V

Unfertilized parcels (June 3rd 1966)

Fertilizer and its amount:	O				$CaSO_4 \cdot 2\,H_2O$							
					27 q/ha				67 q/ha			
Number of parcel series:	I.		III.		I.		III.		I.		III.	
Number of all species:	13		12		12		11		12		8	
Dominance and production amount:	%	P	%	P	%	P	%	P	%	P	%	P
Puccinellion species:												
H Puccinellia limosa	4	3,8	4	3,7	4	4,0	5	5,0	4	4,0	4	4,0
Festucion pseudovinae species:												
H Scorzonera cana	0,2	0,1	0.5	0,4	0,5	0,3	·	·	1	0,2	·	·
Agrostion species:												
H Festuca pratensis	30	34,5	20	26,1	25	33,5	20	26,8	35	48,3	35	48,3
H Alopecurus pratensis	2	2,4	1	1,3	1	1,2	1	1,4	1	1,2	·	·
H Agrostis alba	3	2,3	8	8,0	5	3,4	10	7,7	8	6,4	10	6,3
H Ranunculus sardous	0,5	0,2	2	0,8	·	·	1	0,4	·	·	1	0,5
Molinietalia and Arrhenatheretea species:												
H Phleum pratense	·	·	2	1,4	·	·	2	1,3	·	·	2	1,1
H Arrhenatherum elatius	2	1,3	·	·	1	0,7	·	·	1	0,7	·	·
H Trifolium hybridum	15	9,2	16	9,8	20	13,4	14	8,0	20	11,1	12	7,1
H Trifolium repens	·	·	·	·	0,5	0,2	·	·	·	·	3	2,5
H Lotus corniculatus	8	4,0	4	1,6	10	5,3	5	1,7	10	5,4	2	0,6
H Taraxacum officinale	12	0,3	·	·	1	0,1	·	·	1	0,1	·	·
Bromion and Festuco-Brometea species:												
G Carex stenophylla	2	0,3	3	1,0	1	0,1	1	0,2	1	0,2	·	·
H Poa angustifolia	10	9.6	8	7,3	6	5,5	0,5	0,4	6	5,3	·	·
Association-indifferent species:												
H Lolium perenne	·	·	7	5,6	·	·	12	9,6	1	0,6	·	·
H Mentha pulegium	1	0.1	·	·	·	·	·	·	·	·	·	·

TABLE VI P_2O_5 (90 kg ha) treated parcels June 3rd 1966

Fertilizer and its amount:	O				$CaSO_4 \cdot 2\ H_2O$							
					27 q/ha				67 q/ha			
Number of parcel series:	I.		III.		I.		III.		I.		III.	
Number of all species:	10		11		13		10		11		10	
Dominance and production amount:	%	P	%	P	%	P	%	P	%	P	%	P
Puccinellion species:												
H Puccinellia limosa	5	4,4	5	5,1	4	3,2	5	4,1	4	3,7	3	2,7
Festucion pseudovinae species:												
H Scorzonera cana	.	.	0,2	0,1	0,5	0,4	.	.	0,2	0,1	.	.
Agrostion species:												
H Festuca pratensis	23	33,8	20	30,7	20	24,9	20	28,8	20	27,6	25	38,3
H Alopecurus pratensis	.	.	.	.	3	4,6	.	.	.	.	.	.
H Agrostis alba	6	4,8	7	6,3	7	6,4	8	7,0	6	4,4	8	7
H Ranunculus sardous	0,5	0,2	0,2	0,0	0,5	0,2	1	0,5	0,5	0,3	0,5	2,6
Molinietalia and Arrhenatheretea species:												
H Arrhenatherum elatius												
H Phleum pratense	4	2,4	4	2,3	4	3,8	3	2,4	4	2,4	4	3,4
H Trifolium hybridum	18	13,8	30	23,0	23	16,0	30	21,8	35	25,5	33	26,6
H Trifolium repens	.	.	.	.	0,5	0,2	.	.	.	.	.	.
H Lotus corniculatus	8	4,3	4	2,1	15	9,0	4	2,5	7	4,9	5	2,4
H Taraxacum officinale	.	.	.	.	0,5	0,0	.	.	.	.	.	.
Bromion and Festuco-Brometea species:												
H Poa angustifolia	5	4,0	5	4,3	10	8,0	5	5,0	6	5,3	5	5,0
G Carex stenophylla	1	0,2	3	1,4	.	.	2	0,3	1	0,2	6	2,4
Association-indifferent species:												
H Lolium perenne	3	2,4	4	2,6	2	1,6	6	4,3	6	3,7	6	5,7

TABLE VII

NH$_4$·NO$_3$ (174 kg N/ha) treated parcels June 3rd 1966.

Fertilizer and its amount:	O				CaSO$_4$ · 2 H$_2$O							
					27 q/ha				67 q/ha			
Number of parcel series:	I.		III.		I.		III.		I.		III.	
Number of all species:	6		9		6		8		7		8	
Dominance and production amount:	%	P	%	P	%	P	%	P	%	P	%	P
Puccinellion species:												
H Puccinellia limosa	.	.	8	11,9	.	.	6	7,3	.	.	3	3,4
Festucion pseudovinae species:												
H Scorzonera cana	0,3	0,2	1	1,0	.	.	.	.	1	0,4	0,5	0,4
Agrostion species:												
H Festuca pratensis	20	34,5	18	29,3	22	40,0	20	36,4	30	57,5	27	44,0
H Alopecurus pratensis	.	.	8	14,1	2	3,7	6	6,9	4	7,2	4	6,9
H Agrostis alba	30	40,8	30	40,2	30	39,1	18	22,4	14	19,3	15	18,7
Molinietalia and Arrhenatheretea species:												
H Arrhenatherum elatius												
H Phleum pratense	9	9,4	3	2,9	6	8,2	4	4,6	10	10,9	8	10,0
H Trifolium hybridum	.	.	.	.	.	.	0,5	0,0	.	.	.	.
H Trifolium repens												
H Taraxacum officinale			0,5	0,0	.	.	.	.	.	.	.	.
Bromion and Festuco-Brometea species:												
H Poa angustifolia	35	41,6	25	27,8	35	44,3	35	43,6	25	29,7	30	37,4
G Carex stenophylla	.	.	.	.	.	.	.	.	.	.	.	.
Association-indifferent species:												
H Lolium perenne	5	5,1	3	3,4	5	4,6	4	3,5	6	7,2	5	5,7

Summary

A considerable part of the Pannonicum halophilous vegetation can be found as developed in the eroded solonchak-solonetz soils in the Danube valley. These alkaline meadow associations which belong at most to the different subassociations of *Lepidio-Puccinellietum* are of low species number and are standing on a low degree of succession, depending upon the quantity of sodiumcarbonate-hydrocarbonate. And they are caused also, to a high degree, by the fertilizer deficit of the soil devastating effect of the inland-water erosion. For clearing up this question, in the Autumn of 1963 we arranged an experimental series, repeated two times, under irrigated conditions, in the area of Kiskunlacháza, carrying out also soil-amelioration by dressing the soil with sulphate of lime, apart from phosphorous, nitrogen, and their combination. After we had broken the original *Lepidio-Puccinellietum asteretosum* of the experimental plots, relying on the selective effect of sodium salts, we used a seed mixture composed of several species. In three years we have obtained the following major results:

(1) In spite of the weakly saline solonchak-solonetz soil, a great part of species sprouted, producing multilayer meadow cenoses in the midst of a strong struggle for life. For measuring the different influences, we took for a basis the changes of dominance relations and quantitative output according to species, apart from keeping in mind the changes of air temperature, precipitation, and irrigation conditions on the grass level, as well as those of the subsoil-water level.

(2) In the period after the breaking, soma ephemerous halophytae, first of all *Puccinellietalia* elements like *Matricaria chamomilla v. salina, Cerastium dubium, Hordeum hystrix* appear temporarily en masse.

(3) Az a result of N-doses, at first *Lolium perenne* took the lead, then step by step *Festuca pratensis, Poa angustifolia* and the ancient, resettled *Puccinellia limosa* and *Agrostis alba* prevailed.

(4) As a result of phosphorous, the *Molinietalia* species, represented by the *Papilionaceae: Trifolium hybridum* and *Lotus corniculatus* began more and more to prevail. Their prevalence increased also in the way of seed-spreading. The P-doses have a consequently negative influence on some grass species, particularly on *Festuca pratensis,* even in case of a double treatment (P+N).

(5) In the years after the breaking, the succession of the original *Lepidio-Puccinellietum asteretosum* has become extremely slower; and even it changes after being influenced by the soil amelioration through a systematic irrigation (whose influence on vegetation could not be demonstrated in the first three years) and by the administration of fertilizers, becoming similar to the *Astero—Agrostetum* species combination of the moorlands between Danube and Tisza.

References

ALEXEYENKO, L. N. (1958a): A contribution to the biology and ecology of perennial herbs. Bot. Z. *43.* 1582—1588.

ALEXEYENKO, L. N. (1958b): Bestands-Struktur und Ertrag mehrjähriger Futterplanzen. Dokl. Vses. Ordena Lenina Akad. Sel'skochoz. Nauk i V. J. Lenina *23.* 14—18.

APERDAUNIER, R. (1959): Über die ökologischen Grenzen der Glatthaferwiese (Arrhenatherum elatioris) im Vogelsberg—Zeitsch. f. Acker- u. Pflanzenbau.

ARANY, S. *et al.* (1962): Methods of soil- and fertilizer-examination, Budapest, (Hungarian.)

ARENS, R. (1962): Auswirkung der Saatsstärke auf das Konkurrenzverhalten der Arten und die erste Bestandsbildung bei Weideansaaten. — Z. Acker u. Pflanzenbau *115*. 357—374.

BAEUMER, K.: Konkurrenz in Pflanzenbeständen als Problem der Pflanzenbauforschung. Forschung und Beratung. 99—123.

BALÁZS, F. (1944): Role of ecology in the valuation of grasses. Research Service for Plant Production, 4. Kolozsvár, 1943 (Hungarian).

BALÁZS, F. (1943): Estimate of the grass crop on the basis of ecologic tests. „Agrártudomány" *1*. 26—35. (Hungarian.)

BALÁZS, F. (1961): Importance of the grass fertilization with large doses in „Őrség" — Publ. *8*, Agricult. College in Keszthely. (Hungarian.)

DE BOER, TH. A. (1958): Der Zusammenhang zwischen Grünlandvegetation und Bodeneinheiten, Angew. Pfl. Soz. (Stolzenau) *15*. 74.

BERGH, J. P. van den, and ELBERGEE, W. TH. (1962): Competition between *Lolium perenne* L. and *Anthoxantum odoratum* L. at two levels of phosphate and potash. J. Ecol. *50*. 87—96.

BERNSTEIN, L. and PEARSON G. A. (1956): Influence of exchangeable sodium on the yield and chemical composition of plants. I. Green beans, garden beets clover and alfalfa. Soil Sci *82*. 247—258.

BODROGKÖZY, GY. (1960): Phytozönologische und bodenökologische Untersuchungen an den Sumpwiesen im Süden des Gebietes Kiskunság (Klein Kumanien). Acta Bot. Acad. Sci. Hung. *6*. 171—207.

BODROGKÖZY, GY. (1964): Synökologische Auswertung der erstjährigen Produktion der Szik-Meliorations und Nährstoffdosierungsversuche in Szolnok-Besenyszög. — Agrokémia és Talajtan *13*. 85—100.

BODROGKÖZY, GY. (1962): Cenologicheskaya ochenka travopol'nyh assotsiatsy, zaseannyh psle lushcheniya dernyina zasolenyh pochvah Hortobágy. (Zönologische Bewertung von nach Rasenaufbruch angepflanzten Kleegras assoziationen auf den Szik-Böden von Hortobágy). Acta Agronom. Acad. Sci. Hung. *9*. 196—216.

BODROGKÖZY, GY. and HARMATI, I. (1965): Effect of the rations of water and of the different nutrients, connected with overseeding on the species combination of *Achilleo-Festucetum pseudovinae* in the Danube valley. Acta Biol. Hung. Supl.

BODROGKÖZY, GY. und HARMATI, I. (1965): Die mit Bewässerung verknüpfte Wirkung der verschiedenen Nitrogen- und Phosphordarreichungen für die *Achilleo-Festucetum paeudovinae*-Artenzusammenwetzung der Trockenweiden im Donautal. (Manuskt.)

BOEKER, P. (1954): Bodenreaktion, Nährstoffversorgung und Erträge von Grünlandgesellschaften des Rheinlandes. Z. Pflanzenern. Düngung u. Bodenkde. *66*. 111.

BORNKAMM, R. (1963): Erscheinungen der Konkurrenz zwischen höheren Pflanzen und ihre begriffliche Fassung. Ber. geobot. Inst. ETH. Stiftg. Rübel *34*.

DANCU, B. (1963): Wasserhaushalt und Futterwert der Gründland flanzen. Bayer, landv. Jb. *40*. 215—219.

ECKSTEIN, O. (1934): Die Aenderung mineralischen Zusammensetzung von Wiesen- und Weideplanfzen unter dem Einfluss verschiedener Düngung. 3. Grünland-Kongressbericht, Zürich.

ELLENBERG, H. (1952): Wiesen und Weiden und ihre stndörtliche Bewertung. — Stuttgart.

ELLENBERT, H. (1959): Kausale Vegetationskunde und Grünlandwirtschaft. Probl. des Grundl. *16*. 43—48.

ESKUCHE, U. (1963): Untersuchung des Bodenwasserhaushaltes von Pflazengesellschaften. Deutsche Gewässerkundl. Mitt. 17—20.

GERVAIS, P. (1960): Effect of varying levels of phosphorus and potassium applications on productivity and botanical and chemical composition of a ladino clover-timothy association. Canad. J. Soil. Sci. *40*. 185—198.

GORHAM, E. and PEARSALL, W. H. (1956): Produktion ökologie III. Shoot production in *Phragmites* in relation to habitat. Oikos (Kobenh). *7*. 206—214.

GRANT, E. A. and BROWN, C. S. (1961): Yield and nitrogen uptake of forage seedings as effected by nitrogen fertilization. Canad. J. Plant Sci. *41*. 176—184.

HARMATI, I. (1959): Studies of the Root System of *Puccinellia limosa*. Növénytermelés *8*. 349—357.

HEJNY, S. (1957): Ein Beitrag zur ökologischen Gliederung der Makrophyten der tschechoslowakischen Niederungsgewässer. Preslia 29. 349—368.

HERKE, S. (1962): Über die Rolle der hydrologischen Verhältnisse in der Entstehung der Szik-Böden zwischen der Donau und der Theiss. Publ. d. Agrarwiss. Abt. Ung. Akad. d. Wiss. *21*. 155—180.

HUNDT, R. (1958): Beiträge zur Wiesenvegetation Mitteleuropas I. Die Auenwiesen an der Elbe, Saale und Mulde. Nova Acta Leop. *20*. 1—206.

HUNG, O. J. and WAGNER, R. E. (1963); Effects of phosphorus and potassium fertilizers on legume composition of seven grass-legume muxteres. Agron. J. 55. 16—19.

IVINS, J. D. (1959): The measurement of grassland productivity. Procedings of the University of Nottingham Sith Easter School in Agricultural Science 1959. London: Butterwoths Scient Publ.

KÁROLY, R. (1905): Meadow and pasture cultivation. Budapest, (Hungarian).

KRISTE, A. und WALTER, K. (1955): Bestandesverschiebungen auf Wiese und Weide unter dem Einfluss von Düngung und Nutzung. Mittl. der Florist-soziol. Arbeitsgemeinschaft. N. F. *15*.

KLAPP, E. (1927): Wiesendüngung und Pflanzenbestand. Mitt. D. L. G. *42*. 673—677.

KLAPP, E. (1934): Über Methoden der Grünlandbestandsuntersuchung, Verhdl. berg. III. Int. Grünlandkong r. Zürich, 193—202.

KLAPP, E. (1951); Pflanzengesellschaften des Wirtschaftsgrünlandes. (Als Manuskript gedruckt), Braunschweig-Völkenrode, 1951.

KLAPP, E. (1954): Erträge von Pflanzengesellschaften in Beziehung zu Grundwasser und nährstoffversorgung. Angew. Pflanzensoz. (Stolzenau) *8*.

KLAPP, E. (1962): Über das Verhalten der Wiesenpflanzen bei verschiedener Düngung unter besonderer Berücksichtigung der Stickstoffwirkungen von Düngung und Standort. Bayerlandw. Jb. *39*. 515—527.

KNAPP, R. (1952:) Untersuchungen über die Bodenfeuchtigkeit in verschiedenen Pflanzengesellschaften nach neueren Methoden, Ber. Dsch. Bot. Ges. *65*. 113—132.

KNAUER, N. (1963): Über die Brauchbarkeit der Pflanzenanalyse als Massstab für die Nährstoffversorgung und das Düngebedürfnis von Grünland. Hamburg, u. Berlin.

KOLBAY, E. (1934): Guide-book to sowing and settling new grasses. Keszthely. (Hungarian.)

KOVÁCS, MARGIT (1958): Ecologic conditions of the moorlands of Hungary, Publ. 3—4, Biol. Section, Hung. Acad. of. Sci. (Hungarian.)

KÖNIG, F. (1954): Die neuzeitliche Bewertung der Pflanzen des Dauergrünlandes in Hinblick auf die intensive Bewirtschaftung von Wiesen und Wieden. — Ber. Gründlandtagung 5—37.

KRAUSE, W. (1957.): Pflanzengesellschaften als Anzeiger der Standortbedingungen. Die Umschau 78—81.

KREIL, W., WACKER, G. und KALOFEN, H. (1961): Dreijährige Versuchsergebnisse über die Düngung einer Weide mit verschieden hohen N-Gaben (1958—61). Z. Landeskultur 2. 225—257.

LIET, H. und ELLENBERG, H. (1958): Konkurrenz und Zuwanderung von Wiesenpflanzen. Ein Beitrag zum Problem der Entwicklung neu angelegten Grünlandes. Z. Acker- m. Pflanzenbau *106*. 205—223.

LÜKEN, H. (1962): Saline soils under dryland agriculture in South-eastern Saskatchewan (Canada) and possibilities for their improvement. I. Distribution and composition of water-soluble salts in soils in relation to physiographic features and plant grouth, Plant and Soil *17*. 1—25; 26—48; 49—67.

MARSCHALL, F. (1958): Pflanzensoziologisch-bodenkundliche Untersuchungen an schweizerischen Naturwiesen. III. Die Milchkrautweide, ein Beitrag zur botanischen Klassifikation der Alpweiden, Landw. Jahrb. d. Schweiz N. F. *7*. 81—97.

NELSON, C. E. and ROBINS, J. S. (1957): Nitrogen uptake by Ladino clover-orchardgrass pasture and irrigation as influences moisture nitrogen fertilization and clipping treatments, Agronomy J. *49*. 72—74.

PEARSALL, W. H. and GORHAM, E. (1956): Production ecol. 1. Standing crops of natural vegetation. Oikos (Kobnh.) *7*. 193—210.

RAABE, E. und THOMSON, D. (1955): Über die Bedeutung genauer botanischer Analysen bei Beurteilung von Düngerversuchen auf Grünland. Das Grünland *4*. 5.

RABOTNOV, T. A. (1957): The main forms of changes in meadow vegetation. Bull. Moscov. Obšč. Ispyt. Prir. Otdel. Biol. *62.* 93—103.

RUMBURG, C. B. and COOPER, C. S. (1961): Fertilizer-induced changes in botanical composition, yield, and quality of native meadow hay. Agron. J. *53.* 255—258.

SALVADORI, C. (1954): Wirkungen der Wiesendüngung unter verschiedener Wachstum- und Standortsfaktoren. Das Grünland *3.* 6.

SCHECHTNER, G. (1961): Wirksamkeit der mineralischen Stickstoffdüngung auf Dauerwiesen. Bodenkultur *12.* 207—234.

SCHNEIDER, J. (1954): Ein Beitrag zur Kenntnis der *Arrhenatheretum elatioris* in pflanzensoziologischer und agronomischer Betrachtungsweise. Beitr. z. Geobot. Land-Aufnahme d. Schweiz. *17.* 34.

SEARS, P. D. (1962): Management for high production pastures. Dairyfarming Annual. 129—140.

SEREBYAKOVA, T. I. (1962): The shoot formation and clump forming in *Festuca pratensis* HUDS during the first year of life. Bjull. Mosc. obšč. Ispyt Prir. Biol. *76.* 81—95.

SIEBOLD, M. (1958): Der Einfluss langjähriger statischer Düngung auf Pflanzenbestand, Ertrag und Futterwert auf Dauerwiesen. Bayer, Land. Jb. *35.* Sond. h. *3.* 4—66.

SIMON, U. (1954): Fünfjährige Versuchsergebnisse über die Beziehung zwischen Niederschlagsmenge, Pflanzenbestand, Düngung und Ertrag auf Niedermoorwiesen. Z. f. Pflanzenbau, Pflanzenschutz. *5.* 241.

SOÓ, R. (1964): Synopsis systematico-geobotanica florae vegetationisque Hungariae I. Budapest.

SOÓ, R. and JÁVORKA, S. (1951): Compendium of the Hungarian vegetation I—II. Budapest, (Hungarian).

SPEIDEL, B. (1955): Anvendungsmöglichkeiten und Grenzen pflanzensoziologischer Erkenntnisse im Dienste der Landwirtschaft. Futterbau und Dauergrünland *7.* 1—6.

SPEIDEL, S. (1966): Aenderungen des Pflanzenbestandes von Dauerwiesen bei langjähriger Düngung. Bayerisches Landw. *76.* 43. 214—222.

STOFFERS, A. L. und KNAPP, R. (1962): Experimentelle Untersuchungen über den Einfluss von Überflutungen auf verschiedenen Rasengesellschaften. Ber. dtsch. Bot. Ges. *75.* 250—294.

UBRIZSY, G. (1943): Ecologic examination of the productivity and quality of meadows and pastures I. Mezőgazd. Kut *16.* 311—326. (Hungarian).

VAN'T WOUDT, and BESSEL, D. (1955): Soil moisture and fertility effects on clover, yield. Soil. Sci. *80.* 1—9.

VICHEREK, J. (1962): Typen von Phytozönosen der alluvialen Aue des unteren Thaya-Gebiets mit besonderer Berücksichtigung der Wiesenplfanzengesellschaften. Folia *3.*

VINCEFFY, I., PRÉCSÉNYI, I., KOLTAY, A. und KAPOSI, P. (1954): Untersuchungsergebnisse der Vergesellschaftungsverhältnisse von *Lolium perenne* und *Lolium italicum.* Bot. Közl. 115—133.